# INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 00/00318

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: E21B 33/072
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 4993492 A (CRESSEY ET AL), 19 February 1991 (19.02.91) -- | 1-26 |
| A | US 3638722 A (TALLEY, JR), 1 February 1972 (01.02.72) -- | 1-26 |
| A | GB 2184762 A (NORWARD ENERGY SERVICES LTD.), 1 July 1987 (01.07.87) -- | 1-26 |
| A | GB 2233365 A (OTIS ENGINEERING CORPORATION), 9 January 1991 (09.01.91) -- | 1-26 |

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
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| Name and mailing address of the ISA/<br>Swedish Patent Office<br>Box 5055, S-102 42 STOCKHOLM<br>Facsimile No. +46 8 666 02 86 | Authorized officer<br>Christer Bäcknert / JA A<br>Telephone No. +46 8 782 25 00 |

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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 2670225 A (H.E. MCKINNEY), 23 February 1954 (23.02.54) | 1-26 |

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## INTERNATIONAL SEARCH REPORT

Information on patent family members

04/12/00

International application No.
PCT/NO 00/00318

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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| US 4993492 A | 19/02/91 | AU 582193 B | 16/03/89 |
| | | AU 4933585 A | 22/05/86 |
| | | BR 8505700 A | 12/08/86 |
| | | CA 1252385 A | 11/04/89 |
| | | CN 85108328 A | 09/07/86 |
| | | EP 0183409 A | 04/06/86 |
| | | GB 8428633 D | 00/00/00 |
| | | JP 61117393 A | 04/06/86 |
| | | NO 854520 A | 14/05/86 |
| US 3638722 A | 01/02/72 | NONE | |
| GB 2184762 A | 01/07/87 | CA 1274770 A | 02/10/90 |
| | | GB 8630135 D | 00/00/00 |
| | | NO 865328 A | 01/07/87 |
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| GB 2233365 A | 09/01/91 | BR 9003109 A | 27/08/91 |
| | | GB 8914443 D | 00/00/00 |
| | | GB 9012736 D | 00/00/00 |
| US 2670225 A | 23/02/54 | NONE | |

TRANSLATOR'S DECLARATION

In the matter of
an application for patent
PCT/NO00/00318
by FMC Kongsberg Subsea AS

I, Bjørn H. Christiansen of the firm
J.K. Thorsens Patentbureau A/S, Oslo, Norway,
do hereby declare that I am familiar with both the Norwegian language and the English language and that to the best of my knowledge and belief the following is a true and correct translation of the description, claims and abstract of the priority document from the Norwegian patent application No. 1999 4784.

Oslo, 13 September 2002

Bjørn H. Christiansen

The invention relates to a subsea lubricator device, comprising a blowout preventer assembly, a tool housing assembly and a stuffing box, intended to be located at a subsea Christmas tree.

Moreover, the invention relates to methods of circulating fluids in a subsea lubricator.

Works are performed in an oil or gas well, among others, to stimulate or treat the well to increase production, to replace various equipment such as valves, to make measurements, to monitor the state of the well, or anything else being required.

Treatment of the well, for increasing the production rate or volume, is made after a cost/benefit evaluation. Even if the production from a well may be increased by several factors, the intervention costs may become to high or the work considered being to difficult and time consuming. For onshore or platform wells, having easy access into the Christmas tree and infrastructure in the form of lifting equipment etc., the costs of performing the well intervention will be less relatively to the benefit of the operations. The intervention of subsea wells is much more expensive. A vessel (drilling rig or the like) has to be used, involving large daily expenses and, in addition, time consuming transit to and from the field, and large costs as the work requires much more time. Because of this, the production volume from a platform or onshore well is also up to twice the volume of a subsea well with similar reservoir conditions. As mentioned above this is caused by the more easy access making a better programme for well maintenance practically possible and profitable.

Well intervention may be difficult, as existing barriers have to be removed before entering the well. There are strict rules regarding which measures being required to prevent an uncontrolled blowout during such works. Thus, when well intervention shall be performed, a pressure barrier has be established in the form of a blowout preventer. This may vary from simple stop valves to large drilling BOPs. In addition, circulating fluids in the well may be needed, whereby possible pressure increase in the well may be controlled.

There are two main categories of intervention systems.

1. When there is a need to perform circulation, as during stimulation of the well (chemical treatment or fracturing), a pipe string is used, for instance a coiled tubing. In addition, a closed fluid passage, in the form of a riser, has to be established

between the well and the platform in subsea wells. A subsea blowout preventer is secured at the riser and lowered from the rig and fastened at the top of the Christmas tree. A second pressure control assembly (for intervention) is located at the top of the riser, i.e. at the platform. A coiled tubing injector is located at the pressure control assembly by means of coiled tubing. Moreover, this comprises a sealing device, in the form of a stuffing box or the like, and the coiled tubing is sealingly led therethrough. Thus, the equipment and the tool may be lowered in the well under controlled conditions.

2. When there is no need of circulation, i.e. during simple measurements, or when equipment shall be retrieved/located by means of a wire, a smooth slick line, or a cable suspending an instrument, or a tool. A grease injector head (or stuffing box) is arranged to engage sealingly around the wire, whereby the tool may be run downwardly in the well without escape of oil or gas from the well, and whereby a pressure-proof barrier is ensured. During use of a wire this pressure-proof barrier is achieved by means of a lubricant being continuously injected under pressure into the grease injector head, thereby the name lubricator. Such equipment, therefore, is called a lubricator.

From US patent No. 4.993.492 is known a kind of lubricator for use at a subsea well. The lubricator is located at the top of the riser, in the same manner as discussed above. Through this a tool may be lowered in the well, suspended by the wire, for performing operations.

From US patent No. 3.638.722 is known a subsea lubricator located directly on the Christmas tree at the sea bottom. In this manner the use of a riser is avoided and expenses for installation of the riser are saved. In addition, smaller and more inexpensive vessels may be used. Use of wire instead of pipe string during lowering of equipment in the well involves several advantages, particularly lower weight, more easily handling of equipment and less expenses.

Known types of subsea lubricator consists of the following parts: a lower part, being a pressure safety unit, including valves for controlling the well pressure, cutting of wire, etc.. An upper part comprising a gate tube with. Uppermost is provided a releasable wire gate or stuffing box and possible devices for supply of grease under pressure into the wire gate. This both lubricates the wire, whereby it slides more easily therethrough, and

provides sealing between the wire and the gate, whereby possible well fluids may not be discharged into the environment. The gate tube has a length corresponding to appoximately the length of the tool fastened at the end of the wire. During replacement of a tool the entire stuffing box, with the tool, is withdrawn upwardly to the surface.

Such a lubricator may not be used for circulation in the well. Another disadvantage is the practical problems of being able to circulate out unwanted fluids situated in the lubricator. Thus, in practice these hydrocarbons are circulated out by a return line being provided for conveying hydrocarbons upwardly to the vessel at the surface. This means that the vessel must be equipped with installations for treatment of the hydrocarbons in a proper way, which increases the costs of the operation .

The present invention relates to an improvement of a subsea lubricator.

An object of the invention is to provide a lubricator being less heavy and less expensive, and a simpler system for well intervention.

A second object of the invention is to provide a subsea lubricator comprising means for circulating the well.

A third object of the invention is to provide means, permitting unwanted fluids in the tool to be circulated back into the well instead of up to the vessel.

An additional object of the invention is to provide a subsea lubricator which may be used at large depths.

An important aspect of the invention is to avoid formation of hydrates caused by water coming into contact with hydrocarbones.

The invention shall hereinafter be described with reference to the accompanying drawings, wherein:

Fig. 1 is a diagrammatic sketch showing the components of the system.

Fig. 2 is an elevational view showing the pressure control assembly.

Fig. 3 is a vertical section of the pressure control assembly.

Fig. 3A is an elevational view showing the gate tube assembly.

Fig. 3B is a vertical section along the line A-A on Fig. 3A.

Fig. 3C is a vertical section along the line B-B on Fig. 3A.

Fig. 4 is a horizontal section along the line C2-C2 on Fig. 2.

Fig. 5 is a vertical section showing a detail along the line C1-C1 on Fig. 3.

Fig. 6 is an elevational view corresponding to Fig. 3, of a second embodiment of the invention.

Fig. 7- 11 are diagrammatic sketches of a first circulation method.

Fig. 12-13 are diagrammatic sketches of a second circulation method.

Fig. 14-17 are diagrammatic sketches of a third circulation method.

Fig. 18 is diagrammatic sketch similar to Fig. 1, showing the invention used with a horizontal Christmas tree having a ball valve and a plug,

Fig. 19 is a diagrammatic sketch similar to Fig. 1,showing the invention used with a horizontal Christmas tree having two plugs.

Fig. 20 is a vertical section similar to Fig. 3, of a third embodiment of the invention.

Figs. 21-22 are diagrammatic sketches of the method of circulating, for a horizontal Christmas tree as shown on Fig. 18.

In Fig. 1 are shown diagrammatically the components of a subsea lubricator provided on a conventional Christmas tree. The lubricator consists of three main components, a pressure control assembly 40 which comprises valves controlling the well during the intervention operation. A gate tube assembly 60 comprises a tube for a tool which shall be run downwardly in the well. A stuffing box 64 or a wire gate is located for slidable but sealed leadthrough of the cable or wire suspending the tool. The three components are connected to one another by means of connector devices. In addition, components in the well and the Christmas tree with the connected production tubing are shown.

In addition, all of the components comprise various equipment for guiding, monitoring etc. known within the art. The well is completed by a production tubing 1 having a downhole safety valve 2, in accordance with standard practice. The tubing defines an annulus (not shown) between itself and the well casing. A valve device (not shown) forms fluid communication between the interior of the tubing and the annulus downwards in the well.

The Christmas tree 10 is of a usual type well known by the skilled person and, therefore, only its main features will be described. The Christmas tree is provided on the wellhead with a standard wellhead coupling 11. The Christmas tree is of a type comprising a two-channel completion (dual completion), with a main passage 12 communicating with the

production tubing 1 and a lateral passage 22 being in fluid connection with the well annulus. It is sealingly connected to a production tubing hanger in the wellhead. This permits that fluid can be circulated downwardly into the well through the production tubing and upwardly through the annulus, or vice versa.

In the main passage 12 of the Christmas tree are provided a main valve ("master valve") 14 and a safety valve ("swab valve") 15. An outlet 13, having a wing valve 16, is located between these. The outlet 13 communicates with a pipe 17 ending in a connector 6 for a production tube 5 extending to a manifold, or to a production vessel.

In the lateral passage 22 of the Christmas tree are provided the same type of valves, namely a master valve 24, a safety valve 25 and a wing valve 26. The wing valve is located in a lateral outlet 23 and used for control of a possible overpressure in the well annulus. The outlet 23 may communicate with the pipe 17 through a so-called "crossover" (not shown).

Profiles 19, respectively 29, are machined in the tubing hanger, into which plugs may be inserted for closing the well.

During normal production the top of the Christmas tree 10 is closed by a removable cap, a so-called "tree cap" (not shown). This functions as a secondary barrier (in addition to the valve 15), this being required as a supplementary protection against discharge of oil or gas into the environment. The cap will also prevent water from penetrating into the passages of the Christmas tree. It is removed when work is to be performed in the well.

A tree cap is shaped such that all passages for supply of hydraulic fluid to the valves in the Christmas tree are "routed" through the tree cap. When the cap is removed, this connection is broken. This is done intentionally, as in this manner it is ensured that all of the valves in the Christmas tree are closed and cannot be opened from the control room at the production platform. This is very important as the valves have to be closed when the tree cap is removed for attachment of the LIP assembly to the Christmas tree.

Fig. 18 is a sketch corresponding to Fig. 1, showing the lubricator installed on a horizontal Christmas tree (HXT), indicated generally by the numeral 100, having a ball valve and a plug as the two barriers. The Christmas tree is of known construction and will hereinafter be described only to show the differences between this and the

conventional Christmas tree. In the drawings components having functions corresponding to components in the conventional Christmas tree have been given corresponding reference numerals, with the addition of 100. Similar components have the same reference numerals.

Besides, it shall be noted that an important difference between a conventional and a horizontal Christmas tree is that in the conventional Christmas tree the production tubing is suspended at the wellhead itself, while in a horizontal Christmas tree it is suspended within the Christmas tree. Thus, the annulus extends all through and within the Christmas tree. In a horizontal Christmas tree another important difference is that the master valve is arranged at the side outlet. Moreover, the supply of hydraulic fluid enters via a control module in a horizontal Christmas tree, and not through the tree cap.

Correspondingly as the conventional Christmas tree, the horizontal Christmas tree has a main passage 12 and an outlet 13. In the outlet 13 are provided a master valve 114 and a wing valve 116.

In accordance with regulations a double barrier shall always be established in the Christmas tree, in order to safeguard against discharges from the well. As mentioned above, in the conventional Christmas tree this is provided by the valve 15 and the tree cap, as described above. In a Christmas tree of this type the barriers consist of a ball valve 115 and a plug 118. The ball valve is located in an internal tree cap corresponding to the tree cap discussed previously in connection with the conventional Christmas tree, but arranged, as its name implies, within the upper part of the Christmas tree. The plug is located in a machined profile in the production tubing hanger.

Correspondingly, a master valve 124 and a workover valve 131 are located in a lateral passage 122 of the Christmas tree. A bypass 123, called a "crossover", connects the lateral passage with the outlet 117 from the main passage, for controlling possible overpressure in the well annulus. In this "crossover" a stop valve 132 is located.

Fig. 19 is a diagrammatical sketch corresponding to Fig. 18, wherein the Christmas tree is a horizontal Christmas tree (HXT), indicated generally by the reference numeral 200, having crown plug. This means that the ball valve has been replaced by a plug located in the so-called "internal tree cap". Beyond that, this Christmas tree is identical to the one discussed previously. In the drawing components corresponding to components of

the conventional Christmas tree have been given the same reference numerals with the addition of 200. Similar components have the same reference numerals.

The crown plug 215, replacing the ball valve, is located in the internal tree cap, while the second plug 218 is located in the tubing hanger.

When the well is producing, the master valve 14 (114, 214) and the wing valve 16 (116, 216) are kept open, whereby the well fluids are directed to the outlet 13 and the production line 5. Normally, all the other valves in the Christmas tree are closed.

In the following the pressure control assembly 40 shall be described, referring to Fig 1, and Figs. 2 - 5.

The assembly consists in general of a number of valves which ensure control of the well during intervention. This component will hereinafter be referred to as a LIP-assembly ( "Lower Intervention Package").

In the LIP-assembly are provided a number of valves, controlling the well during intervention. These may for instance be (seen from the bottom upwardly) a support and seal valve (so-called "slip ram") 43, i.e. a valve being able to grip around a cable, or a wire, preventing the tool from falling downwardly in the well, if the wire suspending the tool has to be cut. Further are provided a shear and seal valve (so-called "shear ram") 44 and a stop valve (gate valve) 45. It shall be noted that additional such valves may be present and arranged in another orders than the one discussed above.

The lower part of the LIP-assembly comprises connector means 41 for attachment at the upper end of the Christmas tree. In a preferred embodiment the connector means 41 is part of an adapter 90 comprising, among others, the connector means 41 mentioned above in addition to connector devices for securing the adapter to the LIP-assembly. This means that the lubricator may be easily adapted for use with connector profiles in various types of Christmas trees. In addition, the adapter may have other functions which will be described later.

The adapter shown on Fig. 3 comprises passages 91, 92, communicating with the production passage 12 and the annulus passage 22 in the Christmas tree, respectively. Moreover, the passage 91 communicates with a passage 42 in the LIP-housing. The

passages 42, 91 and 12 have coincident axes, i.e. they extend in-line with one another. Moreover, the adapter comprises passages (not shown) for supply of hydraulic fluid into the valves in the Christmas tree, whereby these may be opened and closed during the intervention process. These are communicating with hydraulic lines (not shown) in the umbilical 30 and are controlled by the control module 49. The valves in the Christmas tree may be opened and closed in this manner during the intervention process.

An additional passage, or bypass 46 is provided in the LIP-assembly. In a preferred embodiment the bypass is formed as a separate pipe 46 connected removably to the side of the LIP-housing, as shown in Fig. 1. The bypass 46 provides a fluid passage around the valves in the LIP-assembly. In the embodiment shown in Figs. 2 - 5 the lowermost of the bypass is inserted into the adapter 90.

Alternatively, the bypass 46 may be formed as a passage in the LIP-housing.

A first valve assembly, indicated generally by 51 in Fig. 1, is located in connection with the LIP-assembly. In a preferred embodiment the valve assembly consists of a number of valves, conduit pieces etc., provided as a part of the adapter 90. However, the skilled person will realize that this may be formed in many ways. The valve assembly may for instance be a part of the adapter.

The components of the valve assembly 51 are shown more detailed on Figs. 4 and 5. It comprises two inlets communicating with the bypass 46 and a fluid supply line 47, respectively. Check valves 55 and 56 may be located in the inlets, enabling fluid to flow only into the valve body. Further, two outlets, namely a first outlet 53 communicating with the main passage 91 in the adapter (and, thereby, the main passage 12 of the well), and a second outlet which via a passage 52 provide fluid communication to a second passage 92 in the adapter communicating with the lateral passage 22 of the Christmas tree. A stop valve 57 is located in the inlet 47. Likewisely, a stop valve 57 is located in the outlet 53. This combination of valves and passages permits that various forms of well circulation may be performed, which will be described more detailed later.

The second part 60 of the lubricator comprises a gate tube 63 for receipt of a tool which shall be inserted in the well. This is removably secured to the LIP-assembly by connecting means 61, whereby the passage 62 in the gate tube is in axial extension of the passage 42 (Fig. 3).

As an additional safeguard shear and support valves 65, 66 may be placed at the upper part of the gate tube.

The lubricator may comprise meters and other equipment for monitoring the work. On Fig. 1 two pressure meters 67a, 67b are indicated diagrammatically.

The gate tube assembly 63 also comprises a bypass 66, correspondingly as the LIP-assembly. The bypass 66 communicates with the bypass 46. As indicated diagrammatically on Fig. 1 the bypass 66 may be a pipe being removably secured to the side of the gate tube. If so, the bypass 66 has to comprise connector means 61a, as shown diagrammatically in Fig. 1. Alternatively, the bypass may be formed as a part of a dual-passage gate tube. A removable bypass 66 will have it own coupling device 61a, as shown diagrammatically on Fig. 1.

When the bypasses 46, 66 are separate components, these are advantageously flexible hoses.

At the upper part of the gate tube assembly a fluid connection 72 is arranged between the gate tube 63 and the bypass 66. In Fig 1 this is shown diagrammatically as a crossover connection 72. A valve 73 is arranged in the crossover 72 in order that the fluid flow from the gate tube into the bypass pipe may be closed. A second inlet is shown as a pipe stub 82 having connector means for attachment to an external fluid supply. The function of this will be explained more detailed later. A stop valve 74 is located in that passage 82.

At the top of the gate tube are provided a stuffing box 64 and a pipe stub 65 which may comprise a connector profile and, possibly, an insertion funnel for easier insertion of the tool to be lowered downwardly in the well.

In practice the stuffing box will be secured removably to the gate tube. This provides the possibility to choose whether the stuffing box shall be situated at the gate tube all the time, and adapted to be opened, whereby the tool may be led therethrough, or lowered downwardly (and withdrawn upwardly) together with the tool.

Now, a practical embodiment of the gate tube shall be described, referring to Figs. 3A - 3C.

The gate tube 63 is made up of a number of pipes screwed together for a length of about 15 meters, enabling receipt of standard types of tools being used during intervention. The gate tube has connector devices at its ends.

A lower sub 75 provides transition between the gate tube and the LIP-assembly. The sub 77 comprises upper connector means 77 for attachment to the gate tube and lower connector means for attachment to the upper connector 61 of the LIP-assembly. This is shown in Fig. 3B, indicating the LIP-assembly by broken lines. In the sub is provided a tool trap 76, shown as a flap valve, which may be closed in order to prevent the tool from falling down in the well.

In the sub is provided a passage 86 providing fluid communication between the passage in the bypass 66 and a passage in the LIP-assembly (Fig. 3) communicating with the bypass 46.

In a preferred embodiment a lower crossover piece 78 is provided on the lower sub 75, comprising an inlet for the bypass 66 and the inlet 89 for the external fluid supply. The valve 74 is located in the inlet.

A upper sub 79 is connected removably to the top of the tool gate tube, and comprises the said control valves 68, 69 and a stuffing box 64. Uppermost the sub ends in a coupling device 65, possibly having an insertion hopper facilitating insertion of the tool into the gate tube.

An upper crossover piece 71 (Fig. 3C) is secured to the sub 79. In the crossover piece 71 is provided a passage 72, communicating with the passage 62 of the gate tube and the passage of the bypass 66. The bypass 66 is secured to the crossover piece 79. A valve 73 is provided in the passage 72.

Again, it shall be referred to Fig. 1. An umbilical 30 extends from the surface to the lubricator. This comprises lines for supply of hydraulic fluid and electricity for controlling the valves in the Christmas tree and the lubricator (as commonly known). In addition are provided lines for supply of chemical fluids, on the Fig. shown, by way of an example, as a supply line 31 for a diluent such as diesel, a line 32 for water, and two lines 33, 34 for a hydrate inhibiting fluid. The connection of the umbilical with the lubricator is shown at 36. Stop valves 31a-33a are provided for the respective passages 31-33, for controlling

the supply of the various fluids. The line 34 is connected to the passage 47 having the stop valve 54. In this manner the fluids mentioned may be supplied in the apparatus, and particularly into the tool gate tube 51. In addition, check valves may also be provided in the passages 31-34 for increased safeguard against discharges if the umbilical should be disconnected by an accident.

A control module 49 is provided on the LIP-assembly for controlling the various functions during the use of the lubricator.

Now, the method of circulating fluids in the lubricator in connection with a well intervention shall be discussed, referring to Figs. 7-11.

At first, when the intervention shall be performed in a well by means of the lubricator according to the invention, the valves 14 (114; 214) and 16 (116; 216) in the Christmas tree must be closed in order to shut in the well. The tree cap is removed and the LIP-assembly 40, having the umbilical 30 connected, is lowered from a vessel and connected to the Christmas tree, and the connection is pressure tested.

Now, the gate tube assembly 60 is lowered downwardly and connected to the LIP-assembly 60. Simultaneously, the bypass 66 also is connected to the bypass 46. The connection is pressure tested. The lubricator is at this state filled with (sea) water. This situation is shown in Fig. 7.

In the embodiment shown the stuffing box is attached rigidly to the gate tube assembly (the sub 79). A tool 8 for performing downhole works in the well is made ready on the vessel and is secured at the end of a wire 7. The tool is lowered downwardly to the lubricator. The stuffing box is opened. A ROV may be present for monitoring and assisting the insertion of the tool into the gate tube assembly.

However, the stuffing box is preferably suspended by the wire 7 before lowering, and lowered with the tool 8, as indicated in Fig. 2B. The tool is inserted in the tool housing 163, and the stuffing box is locked within the sluice sub 180. Then, problems of sealing due to repeated opening and closing of the stuffing box are avoided.

Due to the fact that the lubricator contains water at this stage, the valves 14, 15 and 45 may not be opened for lowering the tool into the well, as this will result in penetration of

hydrocarbons into the lubricator. When hydrocarbons come into contact with the water, this will lead to formation of hydrates in the system. Thus, before the valves may be opened, the percentage of water in the system has to be reduced . This is obtained by supplying hydrate inhibiting fluid which will be mixed with water, and which does not form hydrate together with water. Examples of such hydrate inhibiting fluids are methanol, glycol, or a special fluid called MEG (Methyl Ethyl Glycol). Hereinafter, when referring to methanol, it will be understood that this means any hydrate inhibiting fluid. Supply of methanol is performed until the water content is reduced, whereby risk of formation of hydrate no longer exists.

Now, the valves 14 and 15 in the Christmas tree may be opened (Fig. 8). The valve 33a is opened for supply of methanol into the gate tube 63. Thereby, the water will be displaced therefrom and into the bypass 66, 46 and downwardly in the well via the passage 53. As the percentage of water in the mixture, in this manner being forced downwardly in the well, still may be so large that it may cause unwanted formation of hydrate in the Christmas tree and the well, the valve 54 is also opened for supply of methanol into the flow in the bypass 46, whereby the water content of the fluids being supplied into the well is below the critical limit for formation of hydrate.

Now, all of the passages in the tool will contain a mixture of about 50/50 water and methanol. The valve 45 is opened after the pressure has been balanced at both of its sides. Normally, the valves 43 and 44 are open, and will be closed only in a situation of uncontrolled blowout with the tool downwardly in the well, as these may cut the wire and stop the well pressure.

During extreme conditions hydrate may be formed in the adaper and in the passage 12 above the valve 15 when the valves 14 and 15 are opened. To prevent this, the system may be adjusted for preventing such formation of hydrate. This is accomplished as follows: The valves 45 and 83 are opened. Methanol is supplied through the line 34, 47 and 53. The water is displaced by methanol from this region. Overpressure may be bled through the pipe 82 (by opening the valve 74). Discharges of polluting methanol from the pipe 82 may be prevented by accurate control of the fluid amount and the time.

Now, the tool may be run in the well in order to perform work therein.

After the tool has performed its task down in the well, it is withdrawn up into the gate

tube. Now, the stuffing box may be opened, whereby the tool may be retrieved to the surface. Now, another possible tool may be made ready in the same manner as discussed previously in order to perform other tasks in the well.

However, hydrocarbons, particularly gas, have now entered from the well and gathered in the gate tube and, thus, the stuffing box may not be opened without further, as this will result in discharge of hydrocarbons into the environment. Therefore, hydrocarbons have to be removed from the gate tube and replaced by (sea)water, in order to prevent any risk of pollution when the stuffing box is disconnected and the gate tube again is exposed to the environment, .

Thus, at this stage the gate tube contains hydrocarbons. The bypass 46, 66 contains a mixture of methanol and water. This situation is shown in Fig. 9. Therefore, replacement of the gas and the oil in the gate tube by water (not polluting) is necessary, before the stuffing box is opened. Previously, this was accomplished by circulating the hydrocarbons via the umbilical to the surface, involving the need for expensive collecting and/or processing equipment on the vessel. According to the invention the gas shall be circulated back into the well.

At this stage water is pumped through the pipe 32 and into the gate tube 63. As water has a larger density than the gas, the water will displace the gas in the gate tube and over into the bypass. However, in the bypass water flows downwardly and, in order to ensure that the gas also is forced downwardly in the well, the velocity of the water has to be larger than the rising velocity of the (rising) gas.

This may for instance be achieved in the following manner. The gate tube has a diameter of about 7 inches, while the passage diameter of the bypass is about 1 ½ inches. Thus, the flow velocity of the water is largely increased when it enters the bypass passage, whereby the flow velocity becomes large enough to force the gas downwardly in the well. A flow velocity of 2 m/s in the umbilical will be sufficient to achieve the required flushing velocity in the bypass.

Thus, an important aspect of the invention is providing an efficient circulation in the lubricator (high flow velocity in the bypass) with low flow velocity in the umbilical. By pumping the liquids having low velocity through the umbilical, low pressure losses are obtained, something being particularly important over long distances. High flow velocity

in the umbilical will cause large friction losses, particularly in long umbilicals.

The water being injected contacts the hydrocarbons in the gate tube and may cause formation of hydrates, both in the lubricator and in the well. Therefore, methanol is injected in the water flow in order to avoid this. At a first stage of the circulating both methanol and water (mixture of about 50/50) are injected into the gate tube, while methanol is supplied via the line 34, 47. At a second stage the valve 33a for supply of methanol into the tool housing is closed, but the methanol injection is maintained into the well. This continues until all of the tool has been filled with water. This situation is shown in Fig. 10.

Now, the stuffing box may be opened and the tool withdrawn to the surface. If desired, the tool may be replaced by another tool and the whole operation performed once more. If the operation has resulted in increase of pressure in the lubricator, the pressure may be safely bled by opening the valve 74.

If the intervention work has been completed, the entire lubricator may be withdrawn to the surface. At first, the connector 61 is loosened, and the gate tube is withdrawn. Thereafter, the connector 41 is loosened, and the LIP-assembly with the adapter is withdrawn.

In some cases sticky and semi-liquid oil may gather in the lubricator. If so, this has to be thinned by an appropriate fluid. As an example diesel shall hereinafter be used, but it will be realized that many diluent fluids are available on the market. Diesel is pumped downwardly through the line 31, and into the gate tube 63, and displaces the oil/gas therein. Water being present in the bypass will be forced downwardly in the well. Therefore, methanol is also injected into the well via the lines 34, 47, for preventing formation of hydrates. This situation is shown in Fig. 11.

In order to bring the diesel out of the system at first water and methanol, and thereafter only water are supplied into the gate tube, in the same manner as described above. These displace the diesel being forced via the bypass and into the well. Methanol is injected through the line 47.

In a second embodiment the tool is modified, to enable circulating of the well. Such operations are carried out in order to supply fluids for chemical treatment into the well

(and circulating these out after the treatment has been accomplished). In one alternative the gate tube (and the upper bypass) are disconnected at 61. This situation is shown in Fig. 12. Two supply lines, which may be rigid pipes, hoses, or a combination thereof, having reference numerals 84 and 85, are connected to the LIP-assembly at the connectors 61 and 61a. In a preferred embodiment the supply lines end in a termination head having two passages adapted to the connector 61 (cf. Fig. 3). Alternatively, in a second embodiment the lower sub 75 is maintained. The pipe 85 is connected at 77 (Fig. 3A) and the pipe 84 is connected to the crossover 78 at the stud 82.

The valve 45 is opened, while the valve 57 is kept closed. Thereby, fluid may be circulated downwardly through the bypass 46, further through the branch pipe 52 into the lateral passage 22 in the Christmas tree 10, downwardly in the well annulus. The fluid may flow into the tubing 1 via the valve in the production tubing and upwardly through the passage 12 in the Christmas tree, and therefrom back through the passage 42 in the LIP-assembly and back into the vessel through the tube 85.

The direction of circulating may be reversed, i.e. down the passages 42, 12 and up the passages 22, 52, 42.

In a second alternative the gate tube may be situated at the assembly and the tube 85 be connected above the stuffing box, while the second tube 84 is connected to the entry piece 82. The valve 73 is closed during this operation.

After the circulating has been accomplished the valves in the Christmas tree can be closed and the valve 53 opened. Now, remaining fluid situated in the lubricator may be circulated out before the tubes 84, 85 are disconnected.

The invention enables killing of the well by so-called "bullheading", i.e. forcing fluid downwardly in the well against the well pressure. During a situation when control of the well has been lost (pressure increase), while the tool is located in the well, the rams 43, 44 have to be closed. Thereby, restoring the control of the well will be difficult. With the intervention device according to the invention the bypass still provides access into the well. Thereby, special killing fluids may be pumped into the well through the bypass, whereby the well is "killed" and control is restored.

In a third embodiment the apparatus may be used to shut down the well by insertion of

plugs into the plug profiles in the tubing hanger either in the main passage 19 or in the lateral passage (the annulus passage) 29. During insertion of a plug into the profile 19 an adapter of the kind discussed previously (Fig. 3) is used, the passages 42, 62 of the lubricator being in line with the main passage 12 of the Christmas tree. A running tool is used to run, and to locate, or to retrieve the plug. Circulating out fluids is done in the same manner as previously.

However, when inserting a plug into the profile 29 the main passage 42 has to be brought into axial connection with the annulus passage 22 of the Christmas tree. Another adapter 190 shown on Fig. 6 is now connected to the LIP-assembly. This is designed such that, during attachment of the lubricator to the Christmas tree, the passage 42 of the LIP-assembly extends axially in the extension of the passage 191 in the adapter, which in turn is in connection with the lateral passage 22 in the Christmas tree. Now, as also indicated in Fig. 14, the main passage 12 of the Christmas tree will have fluid communication with the bypass 46 via the passage 192 in the adapter. Thereby, circulation may also be maintained during such operations.

A running tool is run downwardly and inserted into the tool housing in the same manner as discussed previously. Fluids (i.e. water) are circulated back into the well, correspondingly as when the tool is completed for ordinary use, as discussed previouly. This situation is shown in Fig. 15.

Now, the valves 24, 25 may be opened and the tool run downwardly with the annulus plug for setting of this. At this stage, both the tool tube and the bypass pipe contain a mixture of methanol and water (usually 50/50). The main valves 14, 15 in the Christmas tree are closed, while the valves 24, 25 in the lateral passage are open. The downhole safety valve 2 is also closed. This situation is shown in Fig. 16

After the plug has been set, the tool 8 is withdrawn upwardly in the tool gate tube and the valves 24, 25 in the Christmas tree are closed. After this stage, the tool tube will also contain oil and gas which must be removed before the running tool is disconnected. This is accomplished in the same manner as discussed previously. This situation is shown in Fig. 17.

When the gate tube has been filled with water, all the valves can be closed and the stuffing box may be opened and withdrawn to the surface, or possibly the stuffing box is

opened and the tool is withdrawn therethrough. Overpressure in the lubricator may be bled by opening the valve 83, as discussed above.

When performing the reversed operation, i.e. when a plug in the Christmas tree is to be withdrawn, the same method of circulating is applied.

In the embodiment discussed above the apparatus being used for well intervention is shown used with a vertical (conventional) Christmas tree. Hereinafter it shall be discussed, with reference to Figs. 18 and 19, how the apparatus may be used together with horizontal Christmas trees.

In Fig. 18 the Christmas tree comprises a ball valve. This must be opened to achieve access into the Christmas tree. As this is another kind of Christmas tree, another adapter 290 shown on Fig. 20 is used. This adapter comprises a valve actuator (not shown), for opening the ball valve 115 when the LIP-assembly has been connected to the Christmas tree. Also as shown in Fig. 20 the adapter comprises a passage 294 providing the axial extension of the passage 12 up to the passage 42. A second passage 292 provides fluid communication between the bypass 46 and the annulus 293 in the Christmas tree.

A pulling tool 8 for plugs is connected to the wire 7 and the stuffing box 64 is opened, whereby the tool may be inserted into the gate tube 63, as discussed previously. Now, as in embodiments described previously, the gate tube contains water having to be removed or thinned before use. However, in such Christmas trees direct access into the well is not available until the plug 118 has been removed. Thus, pumping of fluids downwardly in the well (or to the tubing) is not possible.

However, this circulation may be achieved by means of the bypass and the adapter according to the invention. The workover valve 131 is opened. Now, there are several alternatives. The preferred embodiment is to open the crossover valve 132. Fluid may now be pumped down into the well, or into the production line 5, if the valve 116 is opened. This situation is shown in Fig. 21.

If the annulus master valve 124 is opened, fluid may be pumped down into the well annulus. However, this may be difficult (undesirable pressure increase) and is not preferred.

The valve 45 can now be opened and the tool can withdraw the plug 118. The valves 131 and 132 are closed. Hydrocarbons in the gate tube may now be circulated into the well, as discussed previously in connection with a conventional Christmas tree. This is shown in Fig. 22.

When the Christmas tree as in Fig. 19 includes two bridge plugs, the method described above must be performed twice. As discussed, water in the gate tube has to be removed by circulating the water through the workover valve. Upon withdrawal of the first plug, access into the well is still not available. The lubricator may now also contain hydrocarbons. Removal of the hydrocarbons is accomplished in the same manner as discussed in connection with the conventional Christmas tree, apart from the hydrocarbons being circulated through the crossover, into the well or into the production line.

When all the barriers have been removed, the procedures of running and circulating are similar to those being discussed above regarding a conventional Christmas tree.

Many other alternatives are possible within the scope of the invention. As an example, during circulating of fluids (hydrocarbons or water) in the system instead of forcing these back to the well, the master valve 14 may be closed and the wing valve 16 be opened, whereby the displaced fluid is forced into the production line. This may be desirable, for instance if the pressure in the well is at a level making it difficult to force the fluids down into the well. As the pressure in the production line may be controlled from the production vessel, an underpressure facilitating the circulating of fluids in the pipe line may for instance be provided.

**PATENT CLAIMS**

1. Subsea lubricator device, comprising a blowout preventer assembly (40), a gate tube assembly (60) and a stuffing box (54), said lubricator being intended to be located at a subsea Christmas tree (10; 100; 200) and having a passage (42, 62) therethrough which communicates with a passage (12, 22) in the Christmas tree, characterized in that it comprises at least one bypass (46, 66) for providing an additional fluid connection to the passages (12, 22) of the Christmas tree.

2. Device according to claim 1, characterized in that the bypass is comprised of lower (46) and upper (66) bypass pipes removably connected to each other.

3. Device according to claim 1 or 2, characterized in that the bypass comprises a fluid connection (72) between the upper bypass pipe (66) and the passage (62) of the gate tube (63) at the upper end of the gate tube, and that the bypass comprises a valve assembly (51) providing fluid connection between the lower bypass pipe (46) and a passage (42) of the blowout preventer (40) at a position below the valves (43, 44) of the blowout preventer.

4. Device according to claim 3, characterized in that the upper bypass pipe (66) comprises a crossover (74), in which is provided connector means (82) for attachment of an external fluid supply source (84, 87).

5. Device according to claim 3, characterized in that the valve assembly (51) comprises a first inlet connected to the first bypass pipe (46), a second inlet (47) connected to an umbilical (30), a first outlet (52) connected to the main passage (12) of the Christmas tree, and a second outlet (53) connected to the annulus passage (22) of the Christmas tree.

6. Device according to claim 5, characterized in that check valves (55, 56) are arranged in the inlets.

7. Device according to claim 5 or 6,

characterized in that a stop valve (53) is arranged in the first outlet (52).

8. Device according to the claim 5 - 7,
characterized in that a stop valve (57) is arranged in the second outlet (53).

9. Device according to claim 5,
characterized in that the valve assembly (51) is a part of an adapter (90; 190; 290)

10. Device according to claim 9,
characterized in that the adapter (90; 190; 290) is removably attached to the blowout preventer (40), and comprises a connector device (41) which may be adapted to connector profiles for various Christmas trees (10).

11. Device according to claim 9 or 10,
characterized in that the adapter (90; 290) comprises a first passage (91; 294) providing an axial connection between the passage (42) in the blowout preventer (40) and the passage (12) in the Christmas tree (10), and a second passage (92) providing fluid connection between the bypass pipe (46) and the annulus passage (22) in the Christmas tree (10).

12. Device according to claim 9 or 10,
characterized in that the adapter (190) comprises a first passage (191) providing an axial fluid connection between the passage (42) in the blowout preventer (40) and the annulus passage (22) in the Christmas tree (10), and a second passage (192) providing fluid connection between the bypass (46) and the production passage (192) in the Christmas tree (10).

13. Device according to claim 10,
characterized in that the adapter (290) comprises a valve actuator.

14. Method of circulating fluids out of a subsea lubricator (40, 60), said lubricator comprising a blowout preventer assembly (40), a gate tube assembly (60), and a stuffing box (64), intended to be located on a subsea Christmas tree (10) and having a passage (42, 62) therethrough which communicates with a passage (12; 22) in the Christmas tree,

characterized in that a fluid is supplied to the gate tube, whereby fluids in the gate tube are displaced into a bypass assembly and therefrom into the well, or into a production line.

15. Method according to claim 14,
characterized in that the supplied fluid is water.

16. Method according to claim 14,
characterized in that the supplied fluid is a hydrate inhibiting fluid.

17. Method according to claim 16,
characterized in that the hydrate inhibiting fluid is methanol or glycol.

18. Method according to claim 14,
characterized in that the supplied fluid is a diluent.

19. Method according to claim 14, for removal of water from the gate tube,
characterized in that fluids are injected in the following steps:
-a hydrate inhibiting fluid is supplied to the gate tube (63), displacing water therefrom during simultaneous injection of a hydrate inhibiting fluid into the well.

20. Method according to claim 14, for removal of hydrocarbons from the gate tube,
characterized in that the fluids are injected in the following steps:
-at a first stage water, along with a hydrate inhibiting fluid are supplied to the gate tube, displacing hydrocarbons from the gate tube into the bypass,
-at a second stage water is supplied to the gate tube, whereby this is filled with water, and
-simultaneously supply of the hydrate inhibiting fluid in the well, whereby formation of hydrates is prevented when the water is forced into the well.

21. Method according to claim 14, wherein the safety valves (43, 44) of the lubricator are closed while a tool (8) being located in the well,
characterized in that a pipe (84) for external fluid supply (87) is connected to the upper bypass (at 82), whereby fluid under high pressure may be pumped downwardly in the well through the lower bypass (46), whereby the well may be killed.

22. Method of circulating fluids in a well using a lubricator according to claim 1, c h a r a c t e r i z e d i n the following steps:

-the gate tube (63) and the upper bypass (66) are disconnected,

-a first supply pipe (85) is connected to the blowout preventer (at 61),

-a second supply pipe (84) is connected to a lower bypass (at 61a), and

-fluid is circulated down in the well through the bypass (46), through an annulus passage (22) of the Christmas tree, and down an annulus in the well, and further into the production tubing (1), up the main passage (12) of the Christmas tree and the passage (42) of the lubricator, back to the surface.

23. Method according to claim 22, c h a r a c t e r i z e d i n that the direction of circulation is reversed.

**ABSTRACT**

The invention relates to a method and a device for intervention in oil and/or gas wells by use of wireline equipment. The device comprises a blowout preventer 40 and a lubricator 60. Along the entire length of the device a bypass device 46, 66 is provided. The bypass device communicates fluid with the device at a point (at 72) at the upper part of the tool tube and at a point (at 51) on the underside of the blowout preventer. This permits removal of gas or oil being present in the device by circulating the hydrocarbons down in the well.